of ethylene is passed into sulphuryl chloride at room temperature no apparent change occurs until the gas has bubbled through for quite a long while. Under certain conditions, however, the colorless liquid suddenly turns greenish-yellow, accompanied by rather a sharp rise in temperature, which during the first two or three hours of the run amounts on the average to approximately 10° C. As the temperature rises, the liquid loses its color, soon to be followed by a gradual fall in temperature, which in the course of a few minutes reaches approximately that of the room. When the gas is passed steadily through the liquid, this remarkable cycle returns again and again uniformly and continually in the same order. At the minimum temperature the liquid invariably turns greenish-yellow (about the color of chlorine), which is a sure signal that the temperature will rise. At the maximum temperature, which is usually in the neighborhood of 35° to 40°, the liquid is colorless. A complete cycle ordinarily requires from 10 to 20 minutes, depending upon conditions, and these cycles may be observed for several hours. In the course of time, however, the cycles become longer and the differences in temperature less pronounced. This is what one would expect. A number of different runs has been made, with the same general results. The accompanying diagram shows very clearly some of the cycles observed when one of the experiments was carried out. An explanation of this interesting phenomenon has not been fully worked out, but the mechanism of the reaction is under investigation. It appears that sulphur dioxide and ethylene chloride (Dutch liquid) are among the products of the reaction. It may be that ethylene and sulphuryl chloride first unite to form an unstable compound which then dissociates into ethylene chloride and sulphur dioxide, or it may be that these products are formed by the interaction of the factors as represented by the following chemical equation:

$$SO_2Cl_2 + C_2H_4 \rightarrow C_2H_4Cl_2 + SO_2$$

William Foster

Princeton University

THE AMERICAN PHILOSOPHICAL SOCIETY. IV

SATURDAY, APRIL 24

Afternoon Session—2 o'clock

William B. Scott, D.Sc., LL.D., president, in the chair

Presentation of a portrait of the late Edward C. Pickering, LL.D., vice-president of the society, 1909–1917, by Vice-president Hale.

Animal luminescence and stimulation: E. Newton Harvey, Ph.D., professor of physiology, Princeton University. (Introduced by Dr. H. H. Donaldson.) The production of light by animals is due to the burning or oxidation of a substance called luciferin in the presence of an enzyme or catalyst called luciferase. It resembles the ordinary artificial methods of illumination by burning in that oxygen is as necessary for animal luminescence as it is for the light of a lamp or tallow candle. It differs in that water is absolutely essential for the light production and no carbon dioxide or heat is produced—at least no carbon dioxide or heat is produced at all comparable to that formed during the burning of such substances as tallow, either in the form of a candle or as food, to supply heat and energy for the body. Light production by animals differs also from light produced by combustion in that the oxidation product of luciferin, oxyluciferin, can be easily reduced to luciferin, which will again oxidize with light production. The reaction is reversible and appears to be of this nature—luciferin + 0 $\rightleftarrows$ oxyluciferin + H_2O. The difference between luciferin and oxyluciferin lies probably in this, that the luciferin possesses two atoms of hydrogen which is removed to form H_2O when the luciferin is oxidized. The H_2 must be added to reform luciferin. Whether the reaction goes in one direction or to the other depends, among other things, on the concentration of oxygen and the presence of a reducing agent. In a mixture of luciferin, luciferase, reducing agent and an abundant supply of oxygen, the reaction goes from left to right (with production of light) to an equilibrium. On removal of oxygen the reaction goes in the right to left direction with reformation of luciferin. Thus, while a firefly is flashing, oxyluciferin is produced and between the flashes oxyluciferin is reduced and is now ready to be again oxidized with light production. We may figuratively describe the firefly as a most extraordinary kind of lamp which is able to make its oil from the products of its own combustion. Not only

is it most efficient so far as the radiation (being all light) it produces is concerned but also most economical so far as its chemical processes are concerned. The above reactions can be demonstrated in a test tube with a mixture of oxyluciferin, luciferase and ammonium sulphide. The ammonium sulphide is probably represented in living cells by reducing enzymes or reductases. If such a test-tube is allowed to stand, oxyluciferin is reduced to luciferin which will luminesce only at the surface of the fluid in the test-tube in contact with air. When the tube is agitated so as to dissolve more oxygen of the air the liquid glows throughout. Even a gentle knock or "stimulus" to the tube is sufficient to cause enough oxygen to dissolve to give a momentary flash of light which is strikingly similar to the flash of light given by luminous animals themselves on stimulation. This suggests that when we agitate a luminous animal or when the luminous gland cells of a firefly are stimulated through nerves with the resultant flash of light, in each case the stimulus acts by increasing the permeability of the surface layer of the cells to oxygen. This then upsets an equilibrium involving the luciferin, luciferase, oxyluciferin, oxygen and reductase within the cell, with the production of light and formation of more oxyluciferin. So long as the luminous cell is resting and unstimulated the tendency is for reduction processes to occur and luciferin to be formed. It must be pointed out that not all sorts of stimulation can be explained in this way, as the stimulation of muscles or nerve fibers may take place in the complete absence of oxygen.

The phosphorescence of Renilla: GEORGE H. PARKER, S.D., professor of zoology, Harvard University. The common sea-pansy, *Renilla*, is found in most southern waters and has long been noted for its phosphorescence. It is a dice-shaped colony of polyps whose upper surface is covered with numerous small whitish patches, the phosphorescent organs. During the day *Renilla* can not be excited to phosphoresce, but at night on stimulation it can be made to glow with a beautiful golden green light. The light is produced in wavelike ripples that spread out from the spot stimulated and run over the upper surface of the animal. They travel at a relatively slow rate that agrees with that at which the nervous impulses of the animal travel. Hence it is concluded that the phosphorescence of *Renilla* is under the control of the nerve-net of the animal which apparently pervades the whole colony.

Feeding habits of pseudomyrmine ants: W. M. WHEELER, Ph.D., Sc.D., professor of economic entomology, Bussey Institution, Harvard University, and IRVING W. BAILEY, assistant professor of forestry, Harvard University. In 1918 the senior author described and figured various stages of the larvæ of *Pachysima* and *Viticola,* two genera of Pseudomyrmine ants from the Congo. Except in their earliest stages these larvæ have the ventral portion of the first abdominal segment much swollen and hollowed out as a peculiar pocket, opening just behind the head. The pocket was called the trophothylax (Wheeler, 1920), because the food, in the form of a subspherical or lenticular, usually dark-colored pellet is placed in it by the worker nurses, so that it is within easy reach of the larva's mouth-parts. As early as 1918 the pellet was known to consist of triturated pieces of insects, but subsequent careful analysis shows that the pellet not only in *Pachysima* and *Viticicola* but also in the two other genera of the subfamily, *Tetraponera* and *Pseudomyrma,* is merely the small pellet ("corpuscle enroulé" or "corpuscle de nettoyage" of Janet), which the worker ant first moulds in its own infrabuccal pocket and which consists of the solid food-particles collected by the ant with the strigils of the fore tibiæ from the surfaces of the antennæ and other parts of the body and carried into the infrabuccal pocket after being wiped off by the tongue and maxillæ. Other ants eventually spit out the pellet, which is commonly a moulded, subspherical conglomerate of diverse particles, such as small pieces of insects, fragments of plant-tissue, fungus spores and hyphæ, pollen grains, etc., and cast it away as refuse, but the worker nurses of the Pseudomyrminæ place it as food in the trophothylax of the larva. Even this, however, is not the whole story. Examination of the mouth of the larva reveals a singular, hitherto undescribed organ, evidently used for reducing the food-pellet to such a finely divided state that it can, when acted on by the digestive juices of the stomach, yield a certain amount of nutriment which the worker ant could not extract from it while it was in the infrabuccal pocket. This larval organ, which may be called the trophorhinium, consists of two flat, opposable plates, corresponding to the dorsal and ventral walls of the buccal cavity, each furnished with very fine, parallel, transverse welts or ridges, which, under a high magnification, are seen to be beset with very delicate chitinous projections or spinules. The ventral usually has more numerous rows of these structures than the dorsal surface. The two sur-

faces are evidently rubbed on one another and thus triturate the substance of the food pellet, only small portions of which are ingested at a time from the trophothylax. In all Pseudomyrmine larvæ and in many larvæ of the other subfamilies, except the Dorylinæ and Cerapachyinæ, the trophorhinium is beautifully developed, although in many ants (Ponerinæ) it must be used for comminuting parts of insects given directly to the larvæ by the workers. In its development the trophorhinium bears a strange resemblance to the stridulatory organs of the petiole and postpetiole of many adult ants. It may, in fact, function also as a stridulatory organ, when the food supply is exhausted, and thus apprise the worker nurses of the larva's hunger. Many ant-larvæ, notably those of the Ectatommiine Ponerinæ and of most genera of Formicinæ, also have elaborate but coarser stridulatory surfaces on the mandibles, so that the larva may be able to produce a variety of sounds and therefore communicate to the nurses more than one need or craving.

On correlation of shape and station in fresh water mussels: A. E. Ortmann, Ph.D., Sc.D., curator of invertebrate zoology, Carnegie Museum, Pittsburgh. Various observers have noticed that freshwater mussels differ in shape according to the localities from which they come, and that, generally speaking, flat or compressed shells are found in the smaller streams, more swollen shells in the larger ones. But these observations have been rather vague and indefinite. The present paper is devoted to the demonstration of this fact by careful measurements and their tabulation on the hand of abundant material from a great number of localities, and it has been found, indeed, that for certain species, such a law does exist, according to which more swollen specimens are found downstream, in the larger rivers, more compressed specimens more upstream, and that in the intermediate stretches of a river, these extremes are connected by gradual transitions.

Evolution principles deduced from a study of the even-toed Ungulates, known as Titanotheres: Henry Fairfield Osborn, Sc.D., LL.D., research professor of zoology, Columbia University.

The Astropotheria: William B. Scott, Sc.D., LL.D., professor of geology, Princeton University.

The middle Cambrian beds at Manuels, Newfoundland, and their relations: B. F. Howell, Jr., B.S., instructor in geology, Princeton University. (Introduced by Professor W. B. Scott.) The beds of Middle Cambrian age at Manuels, near St. Johns, southeastern Newfoundland, are part of a once widespread sheet of marine sediments, deposited millions of years ago off the shore of an ancient continent, which probably stretched across what is now the North Atlantic Ocean and for hundreds of thousands of years formed a land bridge between such parts of North America and Europe as were then above the sea. These beds are of special scientific interest because they contain large numbers of unusually well-preserved fossils, which prove that the creatures that swarmed in the waters then covering much of what is now New England, southeastern Canada and southeastern Newfoundland were of practically the same sort as those living in the seas which at the same period washed over many parts of Scandinavia and the British Isles. North America has probably been joined to Europe in this way several times in the geologic past, so that the animals living in the coastal waters could spread from the one hemisphere to the other; but it is seldom that geologists discover such clear evidence of one of these old connections as that which is presented by the Manuels fossils.

The Michigan meteor of November 26, 1919. Also the glacial anticyclone and the blizzard in relation to the domed surface of continental glaciers: William H. Hobbs, D.Sc., Ph.D., professor of geology, University of Michigan.

On Saturday evening the annual dinner of the society was held at the Bellevue Stratford Hotel and was largely attended, the following toasts being responded to:

The memory of Franklin: Hon. Oscar S. Straus.

Our universities: Dr. John M. Clarke.

Our sister societies: Dr. Harvey W. Wiley.

The American Philosophical Society: Professor Leslie W. Miller.

Arthur W. Goodspeed

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